

USER INTERFACE DESIGN FOR TRAFFIC INCIDENT MANAGEMENT SYSTEMS

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ABSTRACT

Effective and efficient road traffic incident handling is vital to the overall operations of transport management. This task requires operators having fast and accurate means of capturing various incident conditions. In this paper, we describe the project activities of a collaboration that sought to design, develop, and evaluate a new user interface of a computerised incident input form, which will be deployed in the control room of the New South Wales Roads and Traffic Authority Transport Management Centre. A series of user studies has revealed that the new input form design is well ranked by the operators.

INTRODUCTION

Traffic in Sydney is expected to continue to grow. Sydney is experiencing the construction of a number of private motorways and there is increased emphasis on the use of public transport. As a result of these factors, the number of unplanned and planned incidents is increasing. In this context, incidents refer to any event occurring on the road network that affect normal traffic flow, such as car accidents, traffic lights faults, flooding, but also planned road occupancy for works.

The New South Wales (Australia) Roads and Traffic Authority (RTA) Transport Management Centre (TMC) [1] opened in September 1999 in preparation for the Olympics in Sydney 2000. The TMC is responsible for the management of more than 17,000km's of State roads within the state of New South Wales. It operates 24 hours/ 365 days a year and has approximately 50 operators on staff working 12-hour shifts, on a 14-day roster. The Transport Operations Room (TOR) in the TMC is where real time traffic monitoring and incident management occurs. The TOR features 12 operator consoles with control of various TMC resources. Their traffic incident management (TIM) systems support fast detection, verification, response and clearance of incidents, in order to reduce the negative impact of incidents on safety and traffic flow.

A core part of this TIM system is the Central Management Computer System (CMCS), which is used for managing incidents on the road network. This system controls and monitors (directly or by linking to other programs) the following equipment: variable message signs (VMS), variable speed limit signs (VSLS), traffic monitoring stations, weather stations, highway telephones, CCTV cameras, etc. The operators can use these tools to increase the efficiency of road use and monitor congestion. It has a map-based graphical user interface.

An incident is entered into the CMCS through an incident form (CMCS IF). The form and its associated widgets/windows are used by the operators to create, handle, and manage an incident during its life span, so an effective and efficient user interface is crucial. However, the TMC operators use a number of TIM systems with varying degrees of cross-integration. The TMC is committed to continuously improving and further developing its operational systems in order to improve their efficiency and effectiveness. An important goal is to maintain the operators' mental workload and stress to reasonable levels during incident management, for example by offering more integrated and intelligent user interfaces. In this paper, we describe a collaborative project focusing on the design, development, and evaluation of a new user interface for the CMCS IF to be used at the RTA TMC.

CURRENT CMCS IF

The CMCS IF has been used by the TMC for the past 7 years without major change, and has played successful role in helping the operators handle and manage incidents on Sydney's road network. Over time there have been additional event handling functions added such as for Road Occupancies and Towing Events, but the main incident handling windows have not changed significantly. During the same period, incident management work practices in the TMC have changed and TMC has gained a better understanding of what is required for the incident management environment in NSW, and some limitations have emerged due to:

- The increase of the number of traffic incidents due to the increase of traffic volume and complexity of road network;
- The demand for more efficient incident handling with shorter response time and faster clearance;
- The demand for integration with other TIM modules, e.g. online traffic updates.

Setting the focus on the CMCS IF, a project was started in 2006 between the RTA and NICTA in order to provide a new, more integrated and usable user interface to the operators. It started with a detailed analysis of the functionality and usability of the current CMCS IF (shown in Figure 1), unveiling the following issues:

- Difficulty and effort required to search for locations to position accidents;
- Low usability due to pop-up windows, complex presentation, layout, look-and-feel;
- Long time spent on data entry due to over-use of dialog text boxes;
- Many fields and buttons rarely used or redundant;
- Missing functionality, such as events not considered incidents;
- Excessive flexibility of the input form leads to imprecise, incomplete and/or inconsistent recorded data across operators;
- Lack of facilities to notify people via email or SMS of incident information;
- Lack of or incomplete integration with other critical systems;
- Ineffective integration with response plans.

The screenshot shows the 'Incident Edit' window with the following data:

- Incident: **Opened**
- Network: **Yes**
- W/AAR Mode: **After**
- Location: **Lnk M2, LANE COVE GORE HILL FWY - EPPING RD ON/OFF RMPS, SY 170 A13**
- To: **<Undefined>**
- Location Description: **Lnk M2, LANE COVE GORE HILL FWY - EPPING RD ON/OFF RMPS, SY 170 A13**
- Affecting: **Lnk M2, LANE COVE GORE HILL FWY - EPPING RD ON/OFF RMPS, SY 170 A13**
- Direction: **East And West**
- Affected: **All Lanes**
- Local Response: **Suppressed**
- Reason:
- Incident Type: **Accident**
- Sub Type: **Accident**
- Severity: **Closure**
- Category: **Accident**
- Sub Category: **Accident**
- Source: **Operator**
- Sub Source:
- Personal Injury: **No**
- Property Damage: **No**
- Start Date: **Monday**
- Time:
- Anticipated: **More than 1 Hour**
- Base Incident: **None**
- Combined Incidents: **None**
- Incident Manager: **EllelyG**
- TOR Sector: **BRAVO**

Buttons at the bottom include: Match, Show Children, Base, Combine, Apply, Reset, Abort, Help.

Figure 1. A Screenshot of the current CMCS IF

USER-CENTRED DESIGN OF THE NEW FORM

A user-centred design (UCD) approach [2, 3] was adopted in order to design a new incident form that effectively solved the current issues, in a proven manner across operators. The design process involved the understanding of the incident management system, design of requirements for the new form, design and implementation of a mock-up interface to evaluate in a user study, and finally the analysis of the outcomes of this study, in order to provide candidate recommendations for the form design.

REQUIREMENTS EXTRACTION

NICTA carried out a comprehensive analysis of the existing user interfaces for the various parts of the system, highlighting their places into the global data flow. This task was carried out based on past experience with the system, screenshots of the graphical user interfaces, and importantly, on the actual data logs for a week's period.

In parallel to this engineering approach, we also carried out some operator interviews in order to refine the data flow model. This activity aims to reduce the gap between the official, or expected usage of the system and the actual usage, in the field. For example, some data that can be transmitted electronically are sometimes communicated over the phone or indirectly, for the sake of speed or in relation with interpersonal relationships.

Once the system data flow identified with precision, we designed a targeted questionnaire addressing very specific aspects of the interface or flow itself. Operators were asked to provide feedback on the current interface, as well as express their opinions about some potential features of a new interface.

A group workshop was also conducted by the RTA and SERCO with several operators in order to elicit similar requirements as a group. Questionnaire and workshop results were then collated, and analysed in view of general literature, such as generic design guidelines, or ergonomic considerations. They were then used to design the new interface.

MOCK-UP DESIGN AND IMPLEMENTATION

The new incident form was designed based on these requirements, and using some general constraints: maximise information visible on each page, minimise free text entries, and integrate process flow (notification, confirmation, response). A limited but working mock-up was then implemented and tested by operators during a user study, in order to validate this design.

We opted for a combination of permanently accessible commands on the right hand side, and thematic tabbed views on the left hand side. Status bars were also incorporated to provide global information on the event.

Permanent commands groups (Figure 2, red and green border areas)

- Video monitoring: Shortcut to select/display a video feed on the side monitors;
- Direction: Details of affected lanes, for both main road and first cross road;
- Impacts: Estimated impacts on the traffic;
- Options to send/remove updates to the online traffic updates system;
- General buttons: Save, save and exit, cancel, and help;
- Top status bar: Incident number, start time/date, current status and priority;
- Second status top bar: Location and nature of incident, name of operator, sector;
- Bottom status bar: Feedback/errors/help on last command performed.

The screenshot shows the 'Incident Form' interface. The top status bar (green border) displays 'Inc No: 034', 'Start: 18:05, 29/08/06', 'Status: Opened (18:05)', and 'Priority:'. Below this, a second status bar (green border) shows 'Car and Bus Crash - Citybound on VICTORIA RD before WESTBOURNE RD - Major delays', 'Operator: A', and 'Sector:'. The main form is divided into several sections: 'Information Source' (Source: NRMA), 'Location' (Asset: Bridge, Name: VICTORIA RD, Locator: 500m Before, Cross/Landmark 1: WESTBOURNE RD, Cross/Landmark 2: DRUMMOYNE, Suburb: DRUMMOYNE, Map Ref: SYD 343H 1), 'Description' (Event: Cra, Involving: Car, Other: Bus, People, More, Infrastructure Damage: Signs, Markings, Road, Guardrails, Traffic Signals, Other), and 'Permanent' (Video Monitoring: Camera 180, Monitor 2; Direction: VICTORIA RD Citybound 2 lanes, Left & middle, Unknown; WESTBOURNE RD, Unknown; Impacts: Duration 2h, Delays Major; TIRF: Current Status, Last Update 18:08, 29/08/06, Auto, Update, Remove). The 'Description' tab is highlighted with a blue border. The 'Permanent' section is highlighted with a red border. The top and bottom status bars are highlighted with green borders.

Figure 2. Incident Form with Description Tab

Description Tab (Figure 2, blue border area)

- Information source: Nature of informant;
- Location: Details of the location of the incident, including a *Check* button to look up the map reference;
- Description: Nature and details about the incident;
- Infrastructure damage: Details about damages to the infrastructure.

ANALYSIS AND RECOMMENDATIONS

User Study Methodology

Two TMC operators took part in pilot study sessions allowing us to refine the scenario, timing and design. Eleven operators participated in the formal study sessions. They were provided with a 5 minutes introduction to the new incident form, and then asked to use it to handle an incident based on a pre-defined scenario. After completion, they were instructed to use the current system to handle another incident based on a similar scenario. The average time for each session was about 45 minutes.

The group of operators participating the study was composed of 85% males, mostly aged 41-50 (39%) and 51+ (38%). 69% of these operators had more than 3 years experience with the current system.

Objective Usability Assessment of the New Incident Form

Using system logs and video annotation, we analysed usability data such as the number of switches between widgets, groups of widgets, quantity and quality of text input with keyboard. A between-subject analysis reflects a significant decrease in the number of widget switches (One-tailed t-Test, $p=0.0004$, <0.025), and group/window switches (One-tailed t-Test, $p=0.0006$, <0.025), as shown in Figure 3. There is no significant decrease of the number of tab/application switches, though. This reflects a reasonable organisation of the flow at the application level in the current system. However, the data flow inside incident form can be improved significantly.

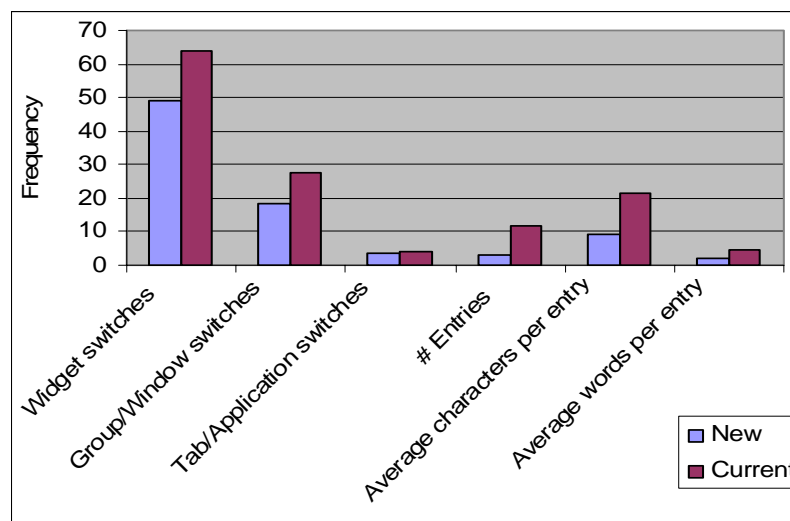


Figure 3. Manual Input Comparison Chart

A between-subject analysis reflects a significant decrease in the number of free text entries (One-tailed t-Test, $p=0.0005$, <0.025), average number of characters per entry (One-tailed t-Test, $p=0.009$, <0.025) and average number of words per entry (One-tailed t-Test, $p=0.002$, <0.025). This seems to indicate that the new CMCS IF can capture more incident related information than the current system.

Subjective Usability Assessment of the New Incident Form

A questionnaire administered immediately after the experiment allowed us to collect subjective rankings on the usability and layout of the new form, as well as general participant comments. The operators rated the usability of the new incident form quite positively as shown in Figure 4. Each score is calculated as the average of ten scores for the same question. The average ratings on a 5-point Likert scale (1: strongly disagree, 5: strongly agree) are shown in red (1st bar in each category). The yellow bars (2nd bar in each category) represent the corresponding standard deviations. This outcome is encouraging given that they only had a few minutes to get used to the new design, which has many new features and functionality.

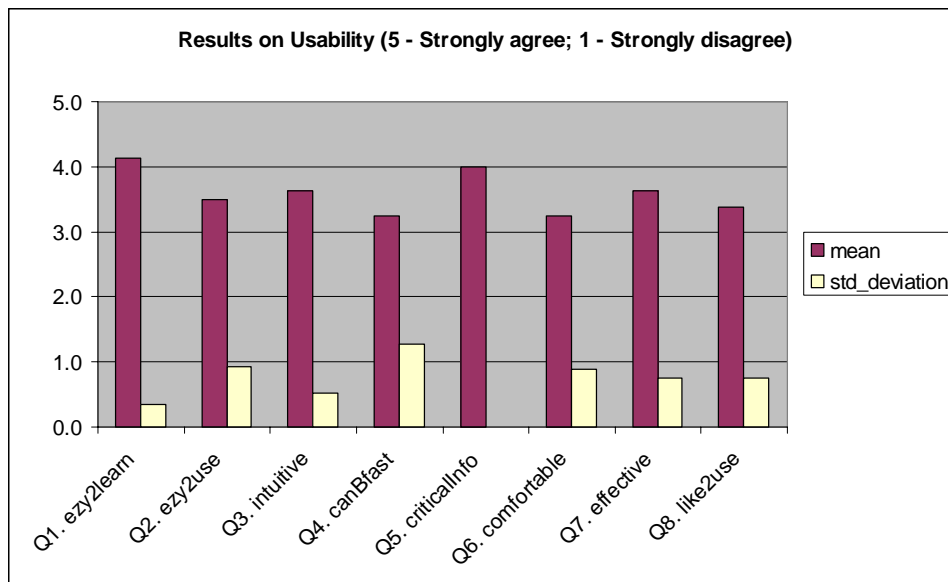


Figure 4. Questionnaire Feedback on the Usability of the New CMCS IF

Subjective Assessment of the UI Aspects of the New Incident Form

Figure 5 shows the average ratings from the operators on 20 questions about the form layout and data organisation.

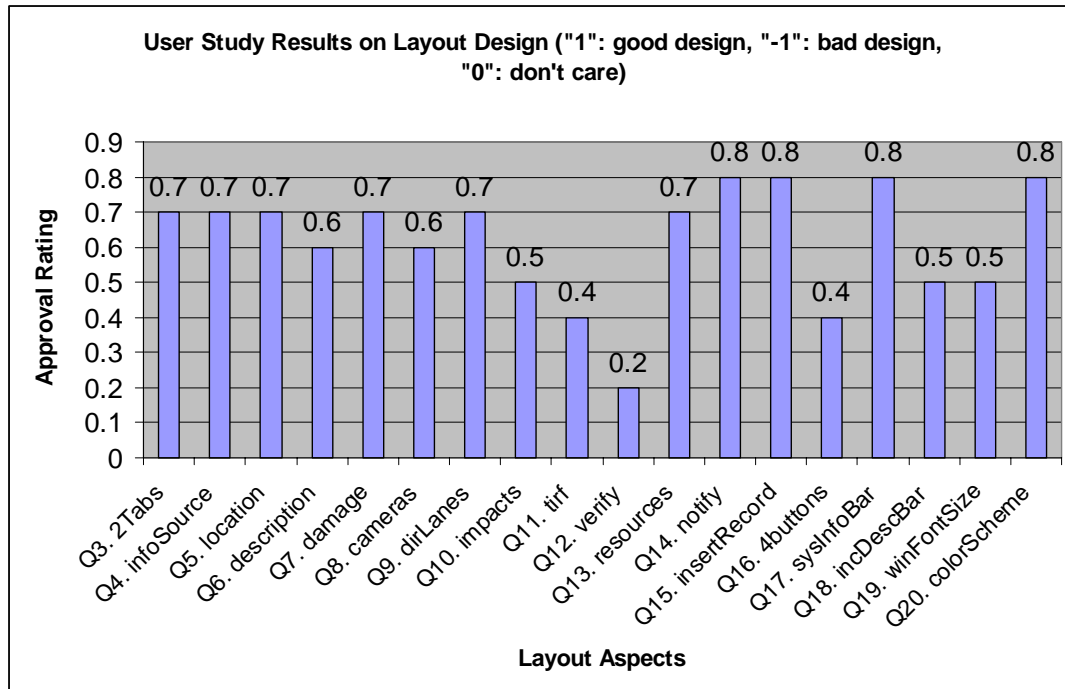


Figure 5. Subjective Assessment of Form Layout and Data Fields Organisation.

Two observations can be drawn from the results:

- The subjects rated quite highly on most of the layout and data organisation aspects of the new incident form;
- The standard deviations for most questions are high and in some cases very high, indicating that the opinions from the operators are quite different. Personal preferences on the form layout may have contributed to the variations.

Recommendations

While the comprehensive set of recommendations is out of scope for this paper, some high-level recommendations include:

- The design of the new CMCS IF should be an iterative process involving design, development and evaluation cycles. The active participation from operators in the scenario design and evaluation stages is crucial;
- The new CMCS IF should bring noticeable improvements, yet leveraging some interactive features of the current form that the operators are familiar with;
- The tabbed layout improves ergonomics by reducing form density, and makes possible the implementation of logical and staged incident handling plans;

- Automation of certain tasks, such as dialling, SMS/Email composition, update of Traffic Incident Reporting Facility (TIRF), is a popular suggestion from operators and should be implemented where possible;
- Built-in system intelligence (automatic filling-in of some form elements based on data already entered) is important for the reduction of handling time and performance;
- A certain degree of user customisation (e.g. lane numbering scheme) may be required to improve effectiveness.

CONCLUSION

We have adopted for a user-centred approach to the design of a new computerised input form for road traffic incident handling. The design process involved understanding of the incident management system, design requirements of the new form, design and implementation of a mock-up for conducting user studies, and finally analysis of the user study outcomes to provide candidate recommendations for the form design. Overall, the new CMCS IF design has been well ranked by the operators as revealed by the user studies. Objective measures from the studies have also showed that the new form helps significantly decrease the amount of manual text input, as well as widget and window switches.

ACKNOWLEDGEMENT

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